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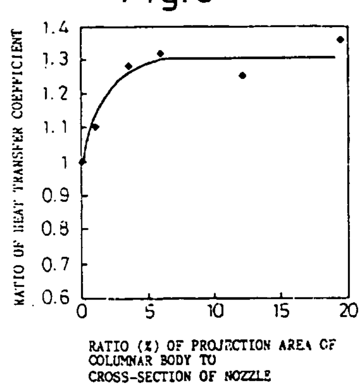
(54) STEEL BAND HEAT-TREATING APPARATUS BY GAS JET STREAM

(57) A heat treatment device, for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprises a baffle body attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle body is determined to be 3 to 12% with respect to an area of a cross-section of the nozzle. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas comprises a baffle plate attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle plate is determined to be smaller than 3% with respect to an area of a cross-section of the nozzle, and a length of the baffle plate in the axial direction of the nozzle is determined to be not less than 50% of the nozzle diameter.

Fig.5



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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat treatment device for heating, cooling or drying a steel strip by blowing a jet of gas onto the steel strip.

BACKGROUND ART

[0002] Conventionally, there is provided a heat treatment device to heating or cooling a steel strip by blowing a jet or gas onto the steel strip. However, since gas is used as a thermal medium for conducting heat transfer in a conventional heat treatment device, the heat transfer coefficient α is low. Therefore, a sufficiently high performance can not be necessarily provided by the conventional heat treatment device, so that a demand for a high heating or cooling rate, which must be accomplished from the viewpoint of metallurgy, can not be satisfied. For example, the present inventors have proposed a cooling device for cooling a steel strip by blowing a jet of gas onto a steel strip, which is disclosed in Japanese Examined Patent Publication No. 2-16375. In the above cooling device for cooling a steel strip, it is assumed that the heat transfer coefficient is in a region of $\alpha \leq 400$ kcal/m^{2}Hr°C. In the case where the heat transfer coefficient is in the above region, it is possible to attain a cooling rate of 100°C/sec when the thickness of the steel strip is 0.6 mm. However, when thickness of the steel strip is 1.0 mm, only a cooling rate of 60°C/sec can be actually attained. For the above reasons, when it is necessary to accomplish a higher heat transfer coefficient, a roll cooling method is used, in which a water-cooled roll is made to come into solid contact with a steel strip, or alternatively a gas-water cooling method is used, in which gas and water are mixed with each other and a steel strip is cooled by the mixture. However, the above roll cooling method is disadvantageous in that the roll comes into solid contact with the steel strip. Therefore, it is difficult to make the water-cooled roll come into contact with the steel strip uniformly. Therefore, the steel strip can not be cooled uniformly, which causes a deterioration in a profile of the steel strip. On the other hand, the gas-water cooling method is disadvantageous in that a surface of the steel strip is oxidized by dissolved oxygen contained in water because water is used for cooling in this method. Therefore, when the above gas-water cooling method is used, it becomes necessary to conduct acid cleaning again on the strip after the completion of heat treatment.

SUMMARY OF THE INVENTION

[0003] In order to enhance the heat transfer coefficient in the heat treatment device for heating or cooling a steel strip by blowing a jet of gas onto the steel strip, it is preferable to increase the flow velocity of gas blown onto the steel strip. According to the experiment made by the present inventors, it has been found that the heat transfer coefficient can be enhanced substantially in proportion to an increase in the flow velocity of gas blown onto the strip. However, in accordance with the increase in the flow velocity of gas, a pressure loss in the piping is sharply increased, and it becomes necessary to provide a very large capacity of blower in order to obtain a predetermined heat transfer coefficient.

[0004] An object of the present invention is to reduce the amount of power required for a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas onto the steel strip while the heating rate or cooling rate is maintained high.

[0005] In order to accomplish the above object, the heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas onto the steel strip of the present invention is characterized as described in the following items (1) to (10).

(1) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising a baffle body attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle body is determined to be 3 to 12% with respect to an area of a cross-section of the nozzle.

(2) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising a baffle plate attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle plate is determined to be smaller than 3% with respect to an area of a cross-section of the nozzle, and a length of the baffle plate in the axial direction of the nozzle is determined to be not less than 50% of the nozzle diameter.

(3) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising: a plurality of nozzles; a plurality of gas blowing headers, to which the plurality of nozzles are attached, for supplying gas to the nozzles; and a gas distributing header for distributing gas to the plurality of gas blowing headers, wherein an opening or a clearance, which is a gas discharge port, is provided between the gas blowing headers, and an area of the opening is

not less than 5 times and not more than 17 times as large as the opening area of the nozzle opening.

(4) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to item (3), wherein the nozzle is a protruding nozzle which protrudes from a forward end portion of the gas blowing header.

(5) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to item (3), wherein a protruding length of the nozzle is not more than 5 times as long as the inside diameter of the nozzle.

(6) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to item (3), wherein a profile of the forward end portion of the gas blowing header is tapering in such a manner that a cross-section of the gas passage is gradually reduced in the direction of blowing gas, and a forward end portion of the nozzle is not protruded from the forward end surface of the gas blowing header.

(7) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: the distance Z from the steel strip to the forward end of the nozzle is determined to be not more than 70 mm, and an inequality of $W/4 \leq h$ is satisfied, wherein a protruding height of the nozzle from the header for supplying gas to the nozzle is h mm, and a quantity of gas (density of quantity of gas) blown onto a unit area is W $m^3/min \cdot m^2$.

(8) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: a roll insertion space, in which presser rolls are alternately arranged at regular intervals along the proceeding direction of the steel strip, is provided in a gas blowing space in which the nozzles for blowing jets of gas are arranged, so as to prevent the steel strip from fluttering; and nozzles for blowing jets of gas are arranged in the roll insertion space on the opposite side to the roll insertion side with respect to the steel strip so as to extend the gas blowing space.

(9) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: a roll insertion space, in which support rolls are alternately arranged at regular intervals along the proceeding direction of the steel strip, is provided in a gas blowing space in which the nozzles for blowing jets of gas are arranged, so as to prevent the steel strip from fluttering; the support rolls are cooled in the case of cooling the steel strip; and the support rolls are heated in the case of heating or drying the steel strip.

(10) A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is cooled by circulating and blowing a non-oxidizing gas onto the steel strip, characterized in that a heat exchanger for cooling gas is arranged at least on the downstream side of a gas compressor such as a blower.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Fig. 1 is a graph showing a relation between the density of quantity of gas and the heat transfer coefficient and also showing a range of the experiment made in the present invention.

Figs. 2(a), 2(b), 2(c) and 2(d) are views respectively showing a nozzle of the heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas of the present invention.

Figs. 3(a) and 3(b) are views respectively showing a state of a jet of gas at a forward end of a nozzle.

Fig. 4 is a graph showing a heat transfer characteristic of a nozzle.

Fig. 5 is a graph showing a relation between a ratio of a projection area of a baffle body to an area of a cross-section of a nozzle, and a heat transfer coefficient at a position immediately under the nozzle.

Fig. 6 is a graph showing a relation between a ratio of baffle plate length/nozzle diameter and a heat transfer coefficient immediately under a nozzle.

Fig. 7 is a view showing a positional relationship between a nozzle and a steel strip.

Figs. 8(a) and 8(b) are views respectively showing a conventional nozzle.

Fig. 9 is a view showing an example of the heat treatment device of the present invention in which an opening for releasing gas to the back side is provided.

Figs. 10(a), 10(b) and 10(c) are views respectively showing an example of the nozzle arrangement of the heat treatment device of the present invention.

Fig. 11 is a view showing a relation between opening portion area S1 and nozzle opening area S2 of a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 12 is a graph showing a relationship between a ratio of an area of the opening portion to an area of the nozzle opening, and a ratio of the heat transfer coefficient of a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Figs. 13(a) and 13(b) are views respectively showing a flow of gas in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 14 is a view showing a portion in which a rising gas flow is generated between the cooling nozzles in a heat treatment device or conducting heat treatment on a steel strip by blowing a jet of gas.

Figs. 15(a) and 15(b) are views respectively showing a structure of the nozzle periphery of a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas of the present invention.

Fig. 16 is a graph showing an influence given to the heat transfer coefficient by the ratio of nozzle protruding length h to nozzle inner diameter D in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 17 is a view showing a relation between the gas blowing header having no opening portion and the nozzle in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 18 is a graph showing a relation between the density of quantity of gas and the ratio of the heat transfer coefficient when a nozzle protruding length h is changed in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 19 is a view showing an arrangement of the support roll and the gas blowing device in a conventional heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 20 is a view showing an arrangement of the support roll and the gas blowing device in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas of the present invention.

Fig. 21 is a cross-sectional view of the advancing and retracting mechanism and the heating and cooling mechanism of a support roll in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 22(a) is a view showing an arrangement of the conventional heat exchanger in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

Fig. 22(b) is a view showing an arrangement of the heat exchanger in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas of the present invention.

Fig. 23 is a graph showing a relation between the ratio of blower power and the gas blowing temperature when a steel strip is cooled in a heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas.

THE MOST PREFERRED EMBODIMENT

[0007] The present invention will be explained in detail as follows. In this connection, the present inventors have investigated various fields in order to solve the problems. In the present invention, problems have been solved from the viewpoints of nozzle formation, gas discharge, ratio of effective gas blowing length, and blowing gas temperature, and these will be successively explained below.

[0008] First, concerning the nozzle formation, in order to optimize the nozzle diameter and nozzle pitch, various experiments were made and the results of the experiments were compared with each other. As a result of the experiments, it was confirmed that the nozzle diameter and nozzle pitch defined by Japanese Examined Patent Publication No. 2-16375 proposed by the present inventors were most effective even if the flow velocity of gas was increased. Fig. 1 shows a range of the experiment made in the present invention and a range of the experiment made in Japanese Examined Patent Publication No. 2-16375. It can be seen in Fig. 1 that a relation between the density of a quantity of gas and the heat transfer coefficient is on an extension line on the graph even in a region, the heat transfer coefficient of which is not lower than 400 kcal/m^{2}Hr°C, unless problems are caused in the exhaust of the gas.

[0009] A stagnation point, which is caused when a jet of gas collides with an object, deteriorates the heat transfer coefficient. Therefore, it is well known that facilitating a turbulence at this stagnation point is effective as a means for enhancing the heat transfer coefficient of gas emitted from the nozzle. For example, as shown in Figs. 8(a) and 8(b), Japanese Unexamined Utility Model Publication No. 61-40155 discloses a structure in which a baffle plate 3 or a spiral line 6 is arranged in the nozzle 1 so as to facilitate a turbulent flow.

[0010] However, in order to arrange the cross baffle plate 3 as described in Japanese Unexamined Utility Model Publication No. 61-40155, the nozzle length must be long so that two or three baffle plates can be arranged in the nozzle. Therefore, it is difficult to industrially manufacture a large number of nozzles having such a structure. When the spiral line 6 is incorporated into the nozzle as described above, gas is agitated and emitted by a centrifugal force. Therefore, this structure is not effective.

[0011] As described before, the intensity of turbulence is low at the center of gas flow. Accordingly, in order to enhance the heat transfer coefficient effectively, it is necessary to increase an intensity of turbulence at the center of gas flow. According to the present invention, as a means for facilitating a turbulence at the center of gas flow, which can be easily put into practical use from the industrial viewpoint, the present inventors proposed a structure in which a baffle body 2 or a baffle plate 3 is arranged at the center of the forward end of the nozzle 1 as shown in Fig. 2. Due to the above structure of the nozzle 1, as shown in Figs. 3(a) and 3(b), there is formed a turbulent flow 5, in which a vortex row is developed, at the rear of the baffle body 2 or the baffle plate 3. Therefore, it becomes possible to make a turbulent flow in the central region of the gas flow 4. In this connection, the cross-section of the baffle body 2 is not limited to a circle, but the

cross-section of the baffle body 2 may be formed into a polygon or other shape.

[0012] Secondly, the present inventors made investigation into a method of discharging exhaust gas emitted from the nozzle. As described before, in order to enhance the heat transfer coefficient, a flow velocity of gas blown onto a steel scrip may be increased. In other words, a quantity of gas blown onto the steel strip may be increased. However, when gas discharge is not sufficiently conducted, gas once blown onto the steel strip remains on a surface of the steel strip and interferes with new gas blown onto the steel strip. As a result, the heat transfer coefficient cannot be greatly enhanced. On the graph of Fig. 1, a solid line expresses an example in which gas discharge is conducted in a good condition, and a dotted line expresses an example in which gas discharge is not conducted in a good condition. When gas discharge is not conducted in a good condition, an increase in the heat transfer coefficient is deteriorated in a region in which the density of air quantity is higher than a predetermined value. For the above reasons, in order to enhance the heat transfer coefficient effectively, it is very important to smoothly discharge gas which has been blown onto a steel strip. In order to solve the above problems, the present inventors found the following two solutions.

[0013] As a result of the investigation of gas blow after the collision of gas with a steel strip, it was found that a jet of gas, which had been emitted from the nozzle, collided with a steel strip and flowed along a surface of a steel strip and then collided with a jet of gas, which had been emitted from the adjacent nozzle, and then flowed in a direction so that gas could be separated from the steel strip. This rising current of gas which rose between the nozzles was generated in the hatched portion in Fig. 14. A flow rate of this rising current of gas was 20 to 40% of the flow rate of the jet or gas emitted from the nozzle 1.

[0014] Therefore, according to the present invention, there is provided an opening portion or a clearance, from which gas is discharged, the area of which is sufficiently large to form a rising current of exhaust gas after a jet of gas emitted from a nozzle collides with a jet of gas emitted from an adjacent nozzle. In this connection, Fig. 11 shows a relation between opening portion area S_1 and nozzle opening area S_2.

[0015] As shown in Fig. 13(a), after a jet of gas emitted from the nozzle 1 has collided with the steel strip 7, it flows on the steel strip 7 and then collides with a jet of gas emitted from the adjacent nozzle and rises upward. As shown in Fig. 13(a), this rising current flows to an end portion of the steel strip in the width direction when no forced ventilation is conducted. Therefore, this rising current is not sufficiently exhausted. Accordingly, it turns back at a surface of the gas blowing header 8 and is mixed with a jet of gas emitted from the nozzle 1. As a result, temperature of the jet of gas emitted from the nozzle 1 is increased when the steel strip is must be cooled, and decreased when the steel strip is must be heated. Therefore, it is impossible to obtain a predetermined capacity of heating or cooling. Since gas remains between the steel strip 7 and the blowing header 8, a flow velocity of a sheet-shaped gas flow on the steel strip 7 is lowered. Accordingly, the cooling capacity is deteriorated in the periphery of the colliding portion of the jet of gas emitted from the nozzle 1.

[0016] In the device according to the present invention, there is provided an opening portion 10 between the gas blowing headers 8 as shown in Fig. 13(b). The rising current flows into this opening portion 10. Consequently the jet of gas emitted from the nozzle 1 reaches a surface of the steel strip while it is seldom affected by the rising current of gas which has turned back. Therefore, the steel strip can be effectively cooled or heated. Since no gas remains between the steel strip 7 and the gas blowing header 8, gas can flow smoothly along the steel strip 7. Therefore, deterioration or the cooling or heating capacity of gas can be mitigated.

[0017] An example of the structure of the nozzle periphery of the heat treatment device of the present invention is shown in Fig. 15. As shown in Fig. 15(a), the nozzle 1 is a protruding nozzle, the forward end of which protrudes more than the forward end portion of the gas blowing header 8. Therefore, when gas is discharged from the opening portion 10, a portion of the jet of gas emitted from the nozzle 1 is prevented from being directly exhausted without colliding with the steel strip. In the example shown in Fig. 15(b), although the forward end of the nozzle 1 is located at the same level as that of the forward end surface of the gas blowing header 8, a profile of the forward end portion of the gas blowing header 8 is tapering, that is, a cross-sectional area of the gas passage is gradually reduced in the gas blowing direction. Therefore, an entrance portion of exhaust gas between the gas blowing headers 8 is tapering. Accordingly, it is possible that a portion in the exhaust gas passage, the area of which is smallest, is assumed to be the opening portion in the case shown in Fig. 15(a). Consequently, it is possible to provide the same effect as that of the structure shown in Fig. 15(a).

[0018] Next, the second gas exhausting method by which gas can be exhausted smoothly will be explained below. According to the first gas exhausting method, gas is released to the rear of the nozzles through the opening portion between the gas blowing headers. However, the first gas exhausting method is disadvantageous in that the gas blowing header is divided into a plurality of portions by the space of the opening portion. For the above reasons, the equipment cost is raised although the first gas exhausting method is ideal. Therefore, according to the second gas exhausting method, the opening portion communicated with the rear side of the nozzle is eliminated, and the nozzle is protruded by an appropriate protruding height. That is, when the nozzle protruding height h shown in Fig. 17 is ensured, interference with blowing gas is eliminated, and no gas remains because a space into which gas is released is formed not at the rear of the nozzle but in the direction parallel to the steel strip. The above method has already been proposed by

the present inventors in Japanese Examined Patent Publication No. 2-16375. According to the above Japanese Examined Patent Publication No. 2-16375, the distance Z from the steel strip to the forward end of the nozzle is defined to be a value not more than 70 mm, and nozzle protruding length h is defined to be a value not less than (100 - Z) mm. However, as described before, the above values are determined on the assumption that an estimated region of the heat transfer coefficient is $\alpha \leq 400$ kcal/m^{2}Hr°C. Experiments were made this time to a region in which the heat transfer coefficient was higher than the aforementioned value, the following were found. The definition is not sufficient, in which the nozzle protruding length h is not less than (100 - Z) mm in accordance with an increase in the quantity of gas. Unless a term or the density W m^3/min · m^2 of a quantity of gas per unit area is added to the evaluation, it is impossible to make an appropriate evaluation reference. That is, the present inventors found that it is important from the physical viewpoint to define a gas discharge space in accordance with a quantity of gas to be blown.

[0019] Therefore, the present inventors made an experiment in which the nozzle protruding height h was changed and a heated steel strip was cooled, so that the relationship between the density of quantity of gas and the ratio of the heat transfer coefficient was found. In this case, the ratio of the heat transfer coefficient was defined as a ratio of the heat transfer coefficient when a heat transfer coefficient was determined to be a reference value. This relation is shown in Fig. 18. According to Fig. 18, when the nozzle protruding height h is 200 mm, the ratio of the heat transfer coefficient is increased substantially in proportional to an increase in the density of a quantity of gas. When the nozzle protruding height h is small, an increase in the ratio of the heat transfer coefficient is suppressed from a certain density of a quantity of gas, and emitted gas remains and interferes with newly emitted gas. This tendency occurs in a region in which the density of quantity of gas is low when the nozzle protruding height h is small. From the above relationship, the following expression can be obtained,

$$W/4 \leq h,$$

where the density of a quantity of gas is W m^3/min · m^2, and the necessary nozzle protruding height is h mm.

[0020] In this connection, concerning the density W of quantity of gas, of course, calculation is conducted with the maximum density of quantity of gas so that the function can be effectively exhibited in all regions of the performance of the device. Concerning the nozzle protruding height h, it is possible to find the smallest height according to the above basis. However, when the height h is unnecessarily extended, a pressure loss in the nozzle is increased and the manufacturing cost of the device is increased. Therefore, it is preferable to select the smallest height which is necessary.

[0021] Thirdly, the present inventors made investigation into a ratio of the effective gas blowing length. Usually, in the case of cooling, the cooling rate is defined as $\Delta t/T$°C/sec, wherein a cooling temperature difference is Δt°C and a period of time required for cooling is T sec. In the case of heating, the heating rate is defined in the same manner as that of the cooling rate. From the metallurgical viewpoint, the cooling and the heating rate are important. In order to enhance the cooling and the heating rate, the present inventors devised the equipment. In the heat treatment device for conducting heat treatment by blowing a jet or gas, in order to enhance the heating rate or the cooling rate, an interval between the nozzle and the steel strip was reduced, so that a decrease in the flow velocity of gas emitted from the nozzle could be prevented as much as one can. Therefore, in order to suppress the warp and flutter of a steel strip, the support rolls 16, 17 were made to come into contact with the steel strip 7 at a certain interval as shown in Fig. 19, so that the warp and flutter of the steel strip could be corrected and an interval between the nozzle 1 and the steel strip 7 could be reduced.

[0022] However, for the reasons of conducting operation, these support rolls 16, 17 are provided with roll supporting devices 18, 19 so that these support rolls 16, 17 can be advanced and retracted in operation. Due to the foregoing, it is necessary to provide support roll insertion spaces in the device, and it is impossible to blow gas into these spaces, that is, the support roll insertion spaces become a useless region from the viewpoint of heat treatment. Due to the existence of these spaces, the heating and the cooling rate are partially lowered, which is disadvantageous from the metallurgical viewpoint. It is important to increase an average heating rate or an average cooling rate in metallurgy. In order to increase these values, it is effective to enhance the efficiency of the gas blowing space, and it is also effective to reduce the support roll insertion space as much as possible.

[0023] In Fig. 19, an effective gas blowing length ratio is defined as a ratio of the length in which gas is actually blown out, to the length L1 from the start to the end of blowing gas. In the conventional case of a continuous annealing apparatus for annealing a steel strip continuously, the effective cooling length ratio was approximately 80%. In order to improve the above circumstances, the present inventors made investigation into a method in which heating or cooling is conducted even in the support roll insertion space. The support roll insertion space shown in Fig. 19 is divided into two sides. One is a side onto which the roll is inserted, ano the other is a side which is opposed to the steel strip wherein no roll is arranged on this side. When an extension 22 of the gas blowing device is arranged on the side on which no roll is arranged as shown in Fig. 20, it is possible to change this side into a gas blowing space. On the side on which the roll is arranged, there is arranged a roll supporting device for advancing and retracting the support roll 16, 17. Therefore, it is difficult to arrange the gas blowing device on this side Even if the gas blowing device is arranged on this side,

it is difficult to make the gas blowing device approach a steel strip. Therefore, the efficiency is lowered. Accordingly, the present inventors devised a device in which the support roll itself is heated or cooled so as to conduct roll heating or roll cooling. Due to the foregoing, the support roll insertion region, which was conventionally a useless region with respect to heating or cooling, can be made very small, and even in the roll insertion region, heating or cooling can be conducted. Due to the foregoing, it becomes possible to enhance the average heating or cooling rate.

[0024] Fourthly, the present inventors made investigation into the optimization of blowing gas temperature in the case of cooling a steel strip. In general, there is a tendency that the power required for a blower is decreased when the blowing gas temperature is decreased. However, when the blowing gas temperature is decreased to a value lower than a predetermined value, in order to decrease the blowing gas temperature, a difference in temperature between the refrigerant used in the heat exchanger and the blowing gas is reduced. Therefore, although a pressure loss in the heat exchanger is increased, the temperature of blowing gas is not decreased so much. As a result, power required for the blower is on the contrary, increased. The present inventors made investigation into the blowing gas temperature in detail. As a result, they found the following. The most appropriate blowing gas temperature, that is, a point at which power required for the blower becomes smallest was approximately in a range from 60°C to 200°C. The present inventors also found that this point fluctuated in accordance with the heat transfer coefficient, the steel strip temperature on the entry side of the heat treatment device, the steel strip temperature on the delivery side of the heat treatment device, and the temperature of refrigerant used in the heat exchanger. The present inventors also made detailed investigation into a region in which the heat transfer coefficient is high. As a result of the investigation, the following were found. In the region in which the heat transfer coefficient was high, the most appropriate point was shifted onto a low blowing gas temperature side compared with the conventional region in which the heat transfer coefficient was low, and the blowing gas temperature greatly affected the power required for the blower as shown in Fig. 23.

[0025] Therefore, the present inventors made investigation into a method by which the blowing gas temperature can be effectively decreased. In a heat treatment device in which a steel strip is cooled when a non-oxidizing gas is circulated and blown onto the steel strip, a heat exchanger in which water is used as refrigerant is commonly used as a cooling method for cooling gas. From the viewpoint of protecting the blower from heat, the heat exchange is conventionally arranged on the entry side of the blower. In this case, in order to decrease the blowing gas temperature, the capacity of the heat exchanger may be increased. However, when a difference in temperature between refrigerant and gas is decreased, the heat exchanging efficiency is deteriorated and a pressure loss is increased when gas flows in the heat exchanger. However, irrespective of the increase in the pressure loss, the blowing gas temperature is not decreased. As a result, as shown in Fig. 23, when the blowing gas temperature is decreased too much, the power required for the blower is, on the contrary, increased. Therefore, the present inventors aimed at an increase in temperature of blowing gas in the case of increasing the pressure of blowing gas by the blower. In accordance with that, the present inventors devised an arrangement in which the heat exchanger is arranged on the delivery side of the blower. That is, instead of installing more heat exchangers on the entry side of the blower, more heat exchangers are installed on the delivery side of the blower. Due to the foregoing, a difference in temperature between gas and refrigerant can be increased, so that the heat exchanging efficiency can be enhanced. Due to the above arrangement, even in the case of the same heat transfer coefficient (α), the same blowing gas temperature can be obtained by a blower power which is lower than that of the conventional arrangement. Especially when an increase in pressure of the blower is enlarged so that the gas blowing velocity onto a steel strip can be increased, the effect can be made remarkable because the gas temperature is greatly increased at the blower.

EXAMPLES

[0026] Examples are successively explained as follows. First, a baffle plate attached to the nozzle will be explained below. Heat transfer characteristics of single nozzles shown in Figs. 2(a) and 2(b) were investigated, wherein a baffle body 2 was attached to a single nozzle shown in Fig. 2(a) and a baffle plate 3 was attached to a single nozzle shown in Fig. 2(b). In this case, air was used as a cooling refrigerant. A nozzle diameter was set at 10.5 mm, a velocity of air emitted from the nozzle was set at 150 m/s, and a distance from the forward end of the nozzle to the object to be cooled was set at 50 mm.

[0027] The characteristic of the nozzle, to the forward end of which the above baffle body was attached, was investigated when a plate at high temperature was cooled with this nozzle. The result of the investigation is shown in Fig. 4. The heat transfer coefficient was enhanced at a position immediately below the nozzle center as shown in Fig. 4.

[0028] Concerning the baffle body, a ratio of the projection area of the baffle body to the cross-section of the nozzle under the above cooling condition is shown in Fig. 5. As can be seen in Fig. 5, the effect of enhancing the heat transfer coefficient can be provided when the ratio of the projection area of the baffle body to the cross-section of the nozzle is not lower than 3%. When the ratio of the projection area of the baffle body to the cross-section of the nozzle is not lower than 12%, a pressure loss at the forward end of the nozzle caused by installing the baffle body is increased. Therefore, the amount of power required for the blower is increased. Therefore, an arrangement in which the ratio of the projection

area of the baffle body to the cross-section of the nozzle is not lower than 12% is not economical. For the above reasons, the ratio of the projection area of the baffle body to the cross-section of the nozzle was determined to be 3 to 12%.

[0029] In the same manner, with respect to the baffle plate, the thickness of which was smaller than 3% of the cross-section of the nozzle, the length of the plate in the axial direction of the nozzle was investigated. As a result of the investigation, it was confirmed that the heat transfer coefficient was enhanced when length of the plate was not less than 50% with respect to the nozzle diameter. Concerning the thickness of the baffle plate, when the thickness was not less than 3%, a pressure loss of blowing gas was increased because of the length of the baffle plate in the axial direction of the nozzle compared with the baffle body described before. Therefore, in order to reduce the amount of power required for the blower, it is advantageous that the thickness of the baffle plate is smaller than 3%.

[0030] Secondarily, an example of the gas exhausting method by which gas is smoothly emitted from the nozzle will be described as follows. Fig. 9 is a cross-sectional view of the heat treatment device of the present invention. There are provided nozzles 1 which are protruded being opposed to the steel strip 7 running in the direction of an arrow. Jets of gas are blown out from the nozzles 1 onto the steel strip 7 so that the steel strip 7 can be heat-treated. In this case, this heat treatment device is used as a heating device when the blowing gas is heated, and this heat treatment device is used as a cooling device when the blowing gas is cooled. In order to prevent the oxidation of the steel strip, in many cases, the heat treatment chamber 12 is filled with non-oxidizing atmosphere, in which hydrogen is mixed with nitrogen. However, even when a gas such as air is used, the same effect can be provided. The arrows shown in Fig. 1 represent currents of gas.

[0031] Gas is continuously supplied from the blower 9. Then, gas is sent to the divided gas blowing headers 8 via a gas distribution header (not shown). A jet of gas, which has been emitted from each nozzle 1 and has collided with the steel strip 7, takes heat away from the steel strip 7. Then, the jet of gas is turned back and exhausted from the opening portion 10. That is, gas is exhausted to the rear side of the nozzle 1 with respect to the steel strip 7. After gas has been exhausted, it is sent to the blower 9 again via the suction gas header 11. The pressure of gas is increased by the blower 9, and then it is recycled.

[0032] Although not shown in Fig. 9, a device for heating or cooling gas is arranged before or after the blower 9. In the arrangement shown in Fig. 9, only gas which has passed through the opening portion 10 via the suction gas header 11 is circulated again, however, it is possible to suck gas from a portion of the heat treatment chamber without providing the suction gas header 11. In this case, a jet of gas emitted from each nozzle 1 collides with the steel strip 7, and then it passes through the opening portion only under the force of a rising current formed by a jet of gas which has been turned back. In Fig. 9, the cross-section of the gas blowing header 8 is rectangular. However, for the reasons of manufacturing the gas blowing header 8, the cross-section of the gas blowing header 8 may be circular, elliptical or polygonal, or, alternatively, the cross-section of the gas blowing header 8 may be a combined shape.

[0033] Fig. 10 is a view showing an arrangement of the nozzles 1 and the gas blowing headers 8, wherein this view is taken on the side of the steel strip. As shown in Fig. 10(a), the nozzles 1 may be arranged in a zigzag manner. Further, as shown in Fig. 10(b), sets of nozzles 1 may be arranged, in a zigzag manner, wherein each set of nozzles 1 is composed of 3 to 7 rows of nozzles 1. When one gas blowing header is arranged for each row of nozzles, the equipment cost is raised. Therefore, as shown in Fig. 10(c), when one gas blowing header is arranged for a plurality of rows of nozzles, it is possible to reduce the number of opening portions. However, in the above case, there is a possibility that the exhaust of gas cannot be performed completely. Accordingly, it is necessary to adjust the nozzle protruding height h in accordance with an area of the opening portion.

[0034] Using the heat treatment device of the present invention shown in Figs. 9 and 10, the steel strip 1, the thickness of which was 1.0 mm, was cooled by blowing a jet of gas wherein a mixed gas of nitrogen and hydrogen was used as a refrigerant. In this case, the cooling nozzle protruding length h was set at 20 mm. In Fig. 12, there is shown a heat transfer coefficient ratio when a ratio of the area of the opening portion to the area of the nozzle opening was changed under the condition of a constant blower power. On Table 1, the nozzle diameter, the nozzle pitch and others are shown. On the graph shown in Fig. 12, a cooling capacity for cooling the steel strip is evaluated by the average heat transfer coefficient in the width direction of the steel strip. The result of a comparative example is shown at the points where ratios of the area of the opening portion to the area of the nozzle opening are 0, 3.4 and 17.3. In this case, when the ratio of the area is 0, all the opening portions are closed. The result of the example is shown in a range from the point where the ration of the area of the opening portion to the area of the nozzle opening is 5.8, to the point where the ratio of the area of the opening portion to the area of the nozzle opening is 15.7. In a range from the point where the ratio is 5, to the point where the ratio is 17, the ratio of the heat transfer coefficient of the example is higher than that of the comparative example. That is, when the ratio of the area of the opening portion to the area of the nozzle opening is 5 to 17, the cooling capacity for cooling a steel strip by blowing a jet of gas is enhanced.

Table 1

	No.	Distance Z (mm) from nozzle to steel strip	Nozzle diameter (inner diameter) D (mm)	Distance (mm) from nozzle to nozzle	Ratio of area of opening portion to area of nozzle opening
Comparative Example	1	50	9.4	50	0
	2	50	9.4	25	3.6
Inventive Example	3	50	10.5	25	5.8
	4	50	9.4	25	7.2
	5	50	12.7	50	7.9
	6	50	10.5	50	11.6
	7	50	9.4	50	14.4
	8	50	7.8	25	15.7
Comparative Example	9	50	10.5	50	17.3

[0035] It is preferable that the protruding length h of the nozzle 1 is not more than 5 times of inner diameter D of the nozzle 1. The reason is that the heat transfer ratio is remarkably lowered, as shown in Fig. 16, when the protruding length h of the nozzle 1 exceeds 5 times of inner diameter D of the nozzle. The reason why the heat transfer ratio is remarkably lowered is thought to be that, when the nozzle protruding length h is large, the flow velocity of gas is decreased until a rising current of gas reaches the opening portion 10 between the gas blowing headers 8 when the nozzle protruding length h is large, so that it becomes difficult for gas to be exhausted.

[0036] Next, an example is shown in which gas is exhausted while the opening portion of the gas blowing header is eliminated and the nozzle protruding height h is set at an appropriate value. This example is shown in Fig. 17. In this arrangement, no openings are provided between the nozzles 1, and the gas blowing header 8 is formed into a box-shaped gas blowing header in which a certain number or nozzles are arranged. In this connection, concerning distance the Z between the forward end of the nozzle and the steel strip 7, as disclosed in Japanese Examined Patent Publication No. 2-16375, it is common that distance Z is set at a value not more than 70 mm.

[0037] Next, referring to Fig. 17, a current 14 of gas will be explained below. After a jet of gas has been emitted from the nozzle 1, it collides with the steel strip 7. Then the jet of gas flows along the steel strip 7. In a short time, the jet of gas collides with a jet of gas emitted from an adjacent nozzle. Therefore, the jet of gas flows in a direction opposite to the direction of the jet of gas emitted from the nozzle, that is, the jet of gas flows from the steel strip 1 toward the gas blowing header 8. After that, this jet of gas collides with the gas blowing header and flows along the gas blowing header. In a short time, this jet of gas passes through a region interposed between the gas blowing header 8 and the steel strip 7 and is exhausted outside. At this time, when the density of the gas is low, a current of gas flowing along the gas blowing header flows in a region of the nozzle protruding height h. However, when the density of the gas is increased, this region is not sufficiently large, so that the current of gas, which has already collided with the steel strip, flows into a region between the steel strip 7 and the forward end of the nozzle 1. In the above state, the current of gas, which has once collided with the steel strip, is involved in a jet of gas emitted from the nozzle. For example, when the steel strip is cooled, a jet of gas emitted from the nozzle is cooled, however, when a current of gas of high temperature, which has already collided with the steel strip, is involved in the jet of gas emitted from the nozzle, the temperature of the jet or gas colliding with the steel strip is raised, so that the cooling efficiency is lowered. In this connection, concerning the gas blowing header, when the height h of the nozzle is determined to be not lower than a predetermined value, gas can be smoothly discharged, however, the gas blowing header may be appropriately divided so that spaces can be formed between the divided gas blowing headers and gas can be discharged through the spaces. Especially when the width of the steel strip is large or the length of the gas blowing header is large in the longitudinal direction, that is, when the size of the gas blowing header is large, it is effective to divide the gas blowing header.

[0038] Thirdly, an example will be shown in which a ratio of the effective gas blowing length is enhanced. Fig. 19 is a view showing a conventional heat treatment device for conducting heat treatment by blowing a jet of gas. The steel strip 7 and the nozzle 1 are made to be close to each other in this arrangement so that the efficiency of a jet of gas can be enhanced. In order to prevent the nozzle from coming into contact with a steel strip when the steel strip flutters or warps,

the steel strip is alternately pressed by the left support roll 16 and the right support roll 17. However, no gas is blown into the left support roll insertion space 23 and the right support roll insertion space 24. Accordingly, although cooling or heating is conducted in the range of L1, useless portions, in which cooling or heating is not conducted, are included in the range of L1. As a result, it is impossible to obtain a high cooling or heating rate. That is, the conventional heat treatment device is in a state in which the ratio of the effective gas blowing length is small.

[0039] Referring to Fig. 20, an example of the present invention will be explained below. In the arrangement shown in Fig. 20, there was provided an extension 22 of the gas blowing device on the opposite side to the support roll with respect to the steel strip 7. Due to the above arrangement, length L2 from the starting position to the ending position of gas blowing was shortened. The actual gas blowing length shown in Fig. 19 is the same as the actual gas blowing length shown in Fig. 20, however, when length L1 is compared with length L2, length L2 is shorter than length L1 that is, the ratio of the effective gas blowing length was enhanced. In this case, a period of time required for heating or cooling was shortened by (L1 - L2)/V seconds, wherein a moving speed of the steel strip 7 is V m/sec. Concerning the heating or the cooling rate, it is possible to increase the heating or the cooling rate in accordance with that. In this connection, when the present invention was applied to an actual continuously annealing device for annealing a steel strip continuously, the ratio of the effective gas blowing length was increased from 82% to 90%.

[0040] As described before, when the support roll is heated or cooled, the heating or the cooling capacity can be enhanced, so that the heating or the cooling rate can be further increased. However, as described before, the heat treatment device, in which the support rolls are directly contacted with a steel strip so as to conduct heating or cooling, since it is generally difficult to make the rollers come into contact with the steel strip uniformly, the heat treatment device is disadvantageous in that the temperature of the steel strip becomes nonuniform. However, according to an experiment made by the present inventors, the diameters or the support rolls are usually not more than 300 mm∅, that is, diameters of the support rolls are usually small. Therefore, a surface pressure of the support roll is higher than that of a commonly used heating or cooling roll, the diameter of which is 1000 mm∅, wherein the surface pressure is defined as a pressure by which the steel strip is pressed against the roll. Therefore, it was found that no problems were caused with respect to nonuniform temperature in the case of heating or cooling.

[0041] Fig. 21 is a cross-sectional view showing the right support roll portion. In this connection, the structure of the left support roll portion is substantially the same as that of the right support roll portion. Therefore, only the right support roll is explained here. In this example, the support roll is a water-cooled roll. As shown in Fig. 21, the right support roll 17 is arranged between both side walls of the heat treatment chamber wall 13 and rotatably supported by the bearings 26 which can be slid on the side walls in the longitudinal direction. In this case, the gas blowing headers and the nozzles are arranged in a clearance on the left of the steel strip 7, however, they are omitted in the drawing for simplification. One end of the right support roll 17, the inside of which is formed into a jacket structure, is connected with a motor 27 for rotating the support roll. On the other hand, the bearing 29 arranged on the opposite side has a rotary joint structure, and a water feed pipe 28 and a drain pipe 29 are connected with the rotary joint. In this case, the bearing 26 is arranged in such a manner that it can slide. Therefore, the bearing 26 can be advanced and retracted by a motor for moving the support roll via a power transmission shaft 31 and a distributor 32.

[0042] Due to the above structure, cooling water can be supplied to the right support roll 17 via the water supply pipe 28, and waste water is discharged outside through the drain pipe 29. In this explanation, the support roll is used as a cooling roll, however, when heated fluid is used, it is possible to use the support roll as a heating roll. Even in the case of cooling, it is possible to use fluid other than water. Further, in the case of heating, instead of using fluid, electric power may be supplied to the roll, so that the roll can be used as an electrically heated roll. It is possible to control a heating or cooling capacity by controlling a temperature or quantity of fluid to be supplied or by controlling an electric current to be supplied to the roll.

[0043] Fourthly, an example will be shown in which the gas blowing temperature is effectively decreased. Fig. 22(a) is a view showing a conventional example of the heat treatment device in which a non-oxidizing gas is circulated and a jet of non-oxidizing gas is blown onto a steel strip so that the steel strip can be cooled. In Fig. 22(a), reference numeral 7 is a steel strip which is an object to be cooled. The steel strip 7 is cooled in non-oxidizing gas (not shown) inside the heat treatment chamber wall 13. Reference numeral 9 is a blower for sucking and blowing the non-oxidizing gas in the heat treatment chamber. This blower 9 sucks gas from the heat treatment chamber via a duct 34. In the middle of this duct 34, there is provided a heat exchanger 35 for cooling gas, and the thus cooled gas is boosted by the blower 9. The thus boosted gas is introduced again into the heat treatment chamber via the duct 34 and blown onto the steel strip 7 via the gas blowing header 8 and the nozzle 1. Therefore, the steel strip 7 can be quickly cooled. Concerning the position of the heat exchanger 35, according to the conventional arrangement, in order to protect the blower 9 from heat, after gas in the heat treatment chamber has been cooled by the heat exchanger, it is sucked by the blower. That is, the heat exchanger is arranged on the upstream side of the blower. In the conventional heat treatment device, an estimated region of the heat transfer coefficient for cooling a steel strip is low. Therefore, the flow velocity at the nozzle end is not high. Accordingly, a high boosting pressure is not required for the blower, and the increase in the gas temperature is small in the blower. For the above reasons, no problems are caused in practical use. However, when the heat transfer

coefficient is raised in the cooling of a steel strip, it becomes necessary to increase the flow velocity at the nozzle end, and a high boosting pressure is required for the blower. For the above reasons, an increase in temperature caused in the process of boosting can not be neglected. As a result, the cooling efficiency can be enhanced when the heat exchanger 35 is also arranged after the blower 9 as shown in Fig. 22(b), that is, the cooling efficiency can be enhanced when the heat exchanger 35 is also arranged on the downstream side of the blower 9. That is, when an amount of decrease in the temperature of atmosphere gas is set to be constant, a capacity of the heat exchanger in the arrangement shown in Fig. 22(b) can be made smaller than that of the heat exchanger in the arrangement shown in Fig. 22(a). As a result, a pressure loss in the heat exchanger is reduced, and a capacity of the blower can be made smaller. In this connection, in the arrangement shown in Fig. 22(b), the heat exchangers are arranged before and after the blower. However, if no problems are caused in the blower from the viewpoint of heat resistance, the heat exchanger arranged on the upstream side may be removed, and the heat exchanger may be arranged only on the downstream side.

INDUSTRIAL AVAILABILITY

[0044] According to the present invention, in the heat treatment device for heating, cooling or drying a steel strip by blowing a jet of gas onto a steel strip, it is possible to enhance the heat transfer coefficient by facilitating a turbulence at the center of the jet of gas, and it is also possible to smoothly exhaust gas which has been blown onto the steel strip and it is possible to prevent the interference of this exhausted gas with gas newly blown onto the steel strip. Due to the foregoing, the heat transfer coefficient can be enhanced.

[0045] According to the present invention, in the heat treatment device for heating, cooling or drying a steel strip by blowing a jet of gas onto the steel strip, the length of useless running sections in the insertion spaces of the right and the left rolls can be shortened, that is, length of sections not contributing to heating, cooling or drying a steel strip can be shortened Therefore, the total length of the heat treatment device can be reduced. Due to the foregoing, it is possible to reduce a period of time for heating, cooling or drying a steel strip, so that the heating rate, cooling rate or drying rate for heating, cooling or drying a steel strip can be enhanced. Further, the heat exchanger for cooling gas is arranged on the delivery side of a gas compressor such as a blower. Due to the foregoing, it becomes possible to effectively lower the temperature of blowing gas. As a result, the cooling efficiency can be enhanced, and power required for a gas compressor such as a blower can be reduced.

[0046] Consequently, it is possible to ensure a heating or cooling rate required from the viewpoint of metallurgy without providing an excessively large capacity of blower or duct. Also, it become possible to shorten the length of the apparatus. Therefore, the apparatus can be made compact and an intensity of power of the blower can be made greatly smaller than that of the blower of the conventional arrangement. Accordingly, from the viewpoint of reducing the running cost, it is possible to provide a great merit. Further, according to the cooling system of the present invention cooling is conducted without causing problems of nonuniform temperature of a steel strip, and also without causing deterioration of a profile of the steel strip and oxidation of a surface of the steel strip caused in the process or cooling with gas and water, which are caused in the roll cooling of the conventional cooling system in which the heat transfer coefficient is $\alpha \geq 400$ kcal/m^{2}Hr°C. Therefore, it is possible to enhance the quality of the steel strip, and it is unnecessary to provide an acid cleaning device for removing an oxide film. Therefore, the apparatus can be simplified.

DESCRIPTION OF REFERENCE NUMERALS

[0047]

1 Nozzle
2 Baffle body
3 Baffle plate
4 Jet of gas
5 Turbulent flow
6 Spiral line
7 Steel strip
8 Gas blowing header
9 Blower
10 Opening portion
11 Suction gas header
12 Heat treatment chamber
13 Heat treatment chamber wall
14 Gas curent
15 Upper conveyance roll

16 Left support roll
17 Right support roll
18 Left roll supporting device
19 Right roll supporting device
20 Lower conveyance roll
21 Gas blowing device
22 Extension of gas blowing device
23 Left supporting roll insertion space
24 Right supporting roll insertion space
25 Gas blowing space
26 Bearing
27 Support roll driving motor
28 Water supply pipe
29 Drain pipe
30 Bellows
31 Transmission shaft
32 Distributor
33 Supporting roll retracting motor
34 Duct
35 Heat exchanger

Claims

1. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising a baffle body attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle body is determined to be 3 to 12% with respect to an area of a cross-section of the nozzle.

2. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising a baffle plate attached to a forward end of a nozzle from which the jet of gas is blown out, wherein a projection area of the baffle plate is determined to be smaller than 3% with respect to an area of a cross-section of the nozzle, and a length of the baffle plate in the axial direction of the nozzle is determined to be not less than 50% of the nozzle diameter.

3. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, comprising: a plurality of nozzles; a plurality of gas blowing headers, to which the plurality of nozzles are attached, for supplying gas to the nozzles; and a gas distributing header for distributing gas to the plurality of gas blowing headers, wherein an opening or a clearance, which is a gas discharge port, is provided between the gas blowing headers, and an area of the opening is not less than 5 times and not more than 17 times as large as the opening area of the nozzle opening.

4. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to claim 3, wherein the nozzle is a protruding nozzle which protrudes from a forward end portion of the gas blowing header.

5. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to claim 3, wherein a protruding length of the nozzle is not more than 5 times as long as the inside diameter of the nozzle.

6. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas according to claim 3, wherein a profile of the forward end portion of the gas blowing header is tapering in such a manner that a cross-section of the gas passage is gradually reduced in the direction of blowing gas, and a forward end portion of the nozzle is not protruded from the forward end surface of the gas blowing header.

7. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: distance Z from the steel strip to the forward end of the nozzle is determined to be not more than 70 mm, and an inequality of $W/4 \leq h$ is satisfied, wherein a protruding height of the nozzle from the header for supplying gas to the nozzle is h mm, and a quantity of gas (density of quantity of gas) blown onto a unit area is W $m^3/min \cdot m^2$.

8. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: a roll insertion space, in which support rolls are alternately arranged at regular intervals along the proceeding direction of the steel strip, is provided in a gas blowing space in which the nozzles for blowing jets of gas are arranged, so as to prevent the steel strip from fluttering; and nozzles for blowing jets of gas are arranged in the roll insertion space on the opposite side to the roll insertion side with respect to the steel strip so as to extend the gas blowing space.

9. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is heated, cooled or dried by blowing the jet of gas onto the steel strip, characterized in that: a roll insertion space, in which support rolls are alternately arranged at regular intervals along the proceeding direction of the steel strip, is provided in a gas blowing space in which the nozzles for blowing jets of gas are arranged, so as to prevent the steel strip from fluttering; the support rolls are cooled in the case of cooling the steel strip; and the support rolls are heated in the case of heating or drying the steel strip.

10. A heat treatment device for conducting heat treatment on a steel strip by blowing a jet of gas in which the steel strip is cooled by circulating and blowing non-oxidizing atmosphere gas onto the steel strip, characterized in that a heat exchanger for cooling gas is arranged at least on the downstream side of a gas compressor such as a blower.

Fig.1

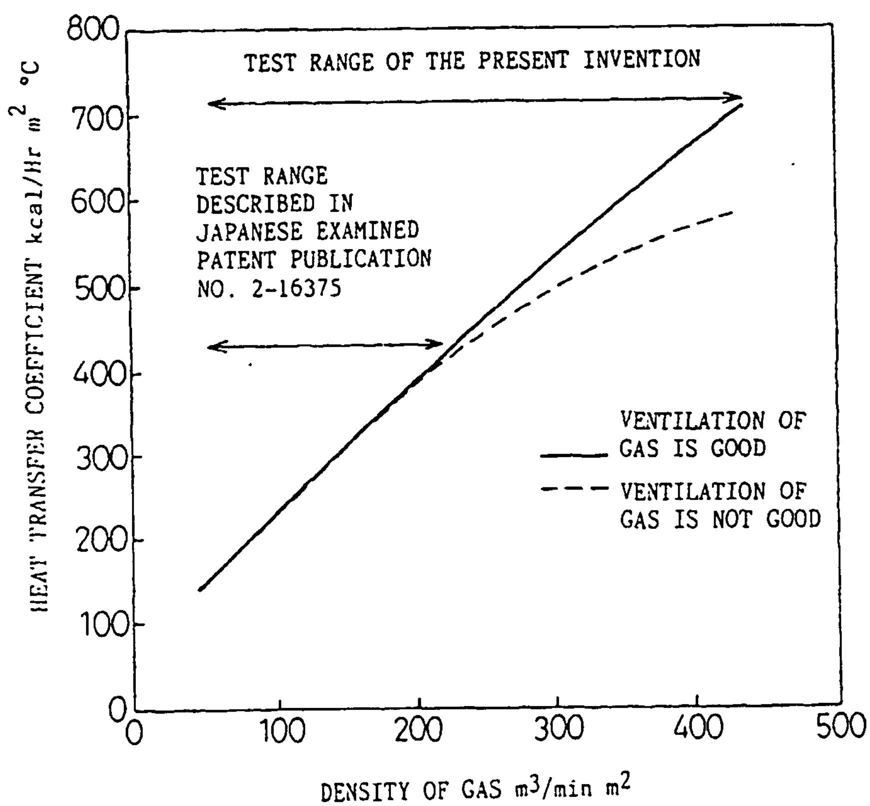

800
700
600
500
400
300
200
100
0
HEAT TRANSFER COEFFICIENT kcal/Hr m2 °C
TEST RANGE OF THE PRESENT INVENTION
TEST RANGE
DESCRIBED IN
JAPANESE EXAMINED
PATENT PUBLICATION
NO. 2-16375
VENTILATION OF
GAS IS GOOD
VENTILATION OF
GAS IS NOT GOOD
0
100
200
300
400
500
DENSITY OF GAS m3/min m2

Fig. 2(a)

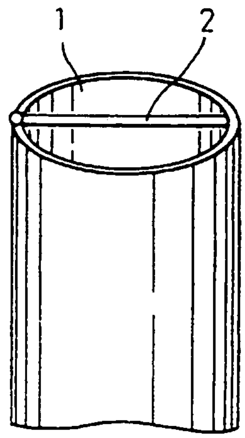


Fig. 2(b)

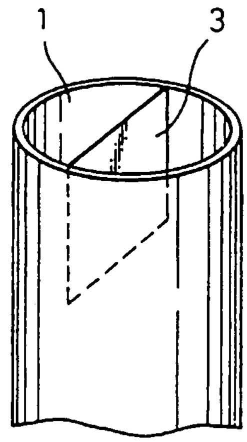


Fig. 2(c)

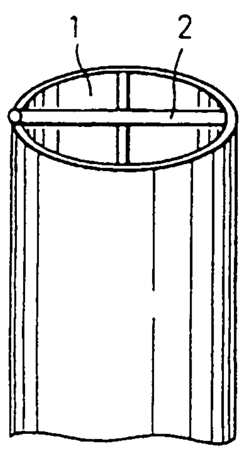


Fig. 2(d)

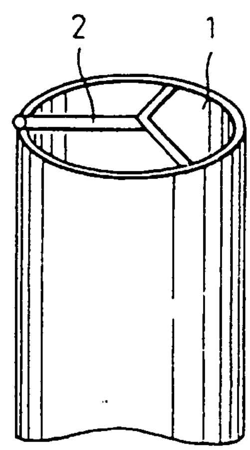


Fig. 3 (a)

Fig. 3 (b)

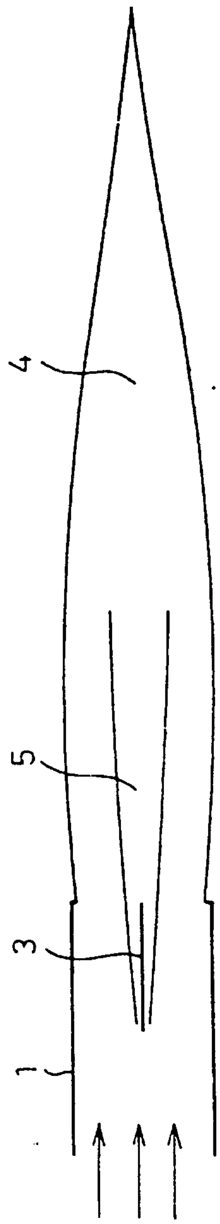


Fig.4

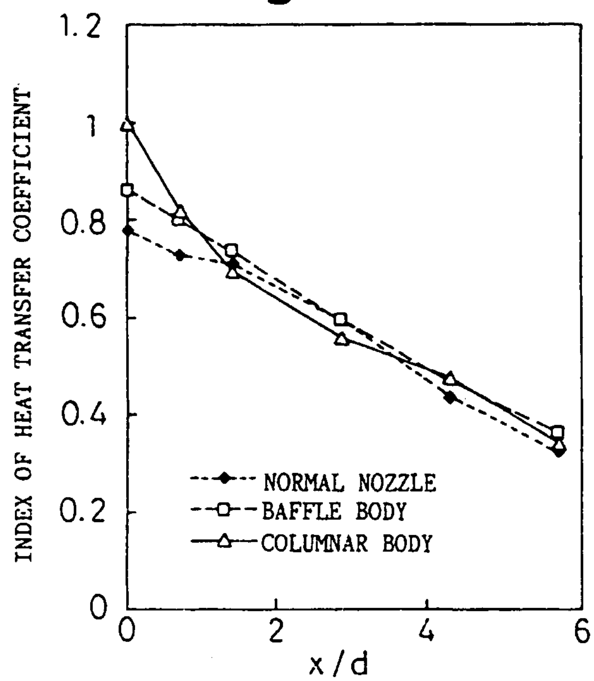

INDEX OF HEAT TRANSFER COEFFICIENT
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
x/d
NORMAL NOZZLE
BAFFLE BODY
COLUMNAR BODY

Fig.5

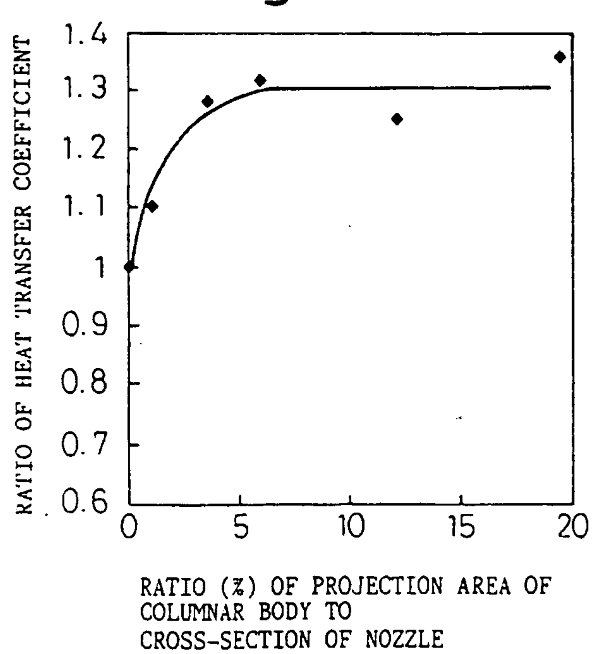

RATIO OF HEAT TRANSFER COEFFICIENT
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0
5
10
15
20
RATIO (%) OF PROJECTION AREA OF
COLUMNAR BODY TO
CROSS-SECTION OF NOZZLE

Fig.6

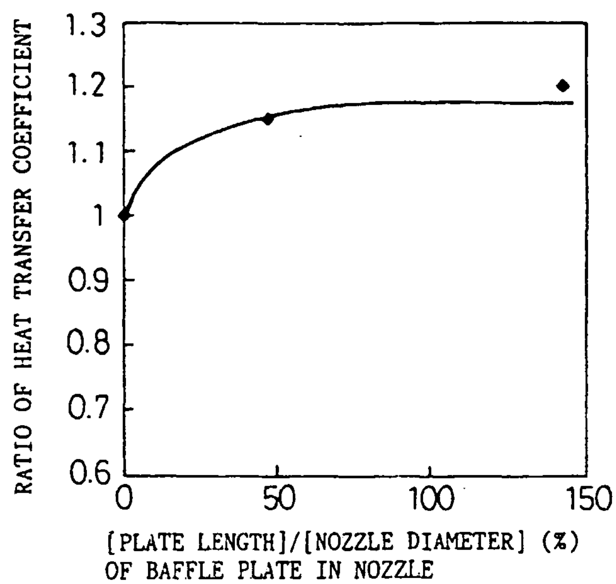

RATIO OF HEAT TRANSFER COEFFICIENT
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0
50
100
150
[PLATE LENGTH]/[NOZZLE DIAMETER] (%)
OF BAFFLE PLATE IN NOZZLE

Fig.7

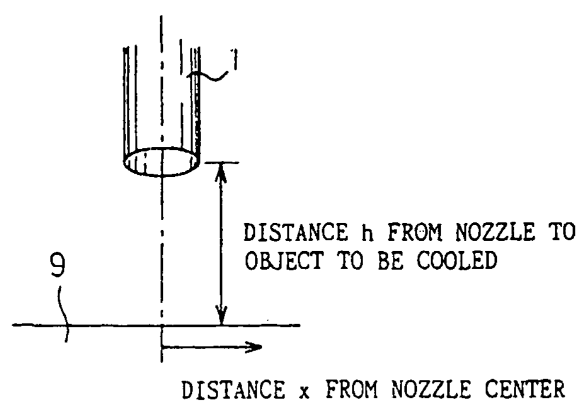

1
DISTANCE h FROM NOZZLE TO
OBJECT TO BE COOLED
9
DISTANCE x FROM NOZZLE CENTER

Fig. 8 (a)

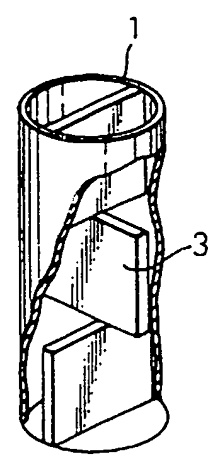


Fig. 8 (b)

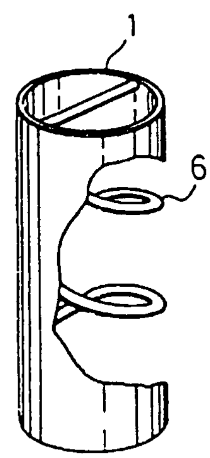


Fig.9

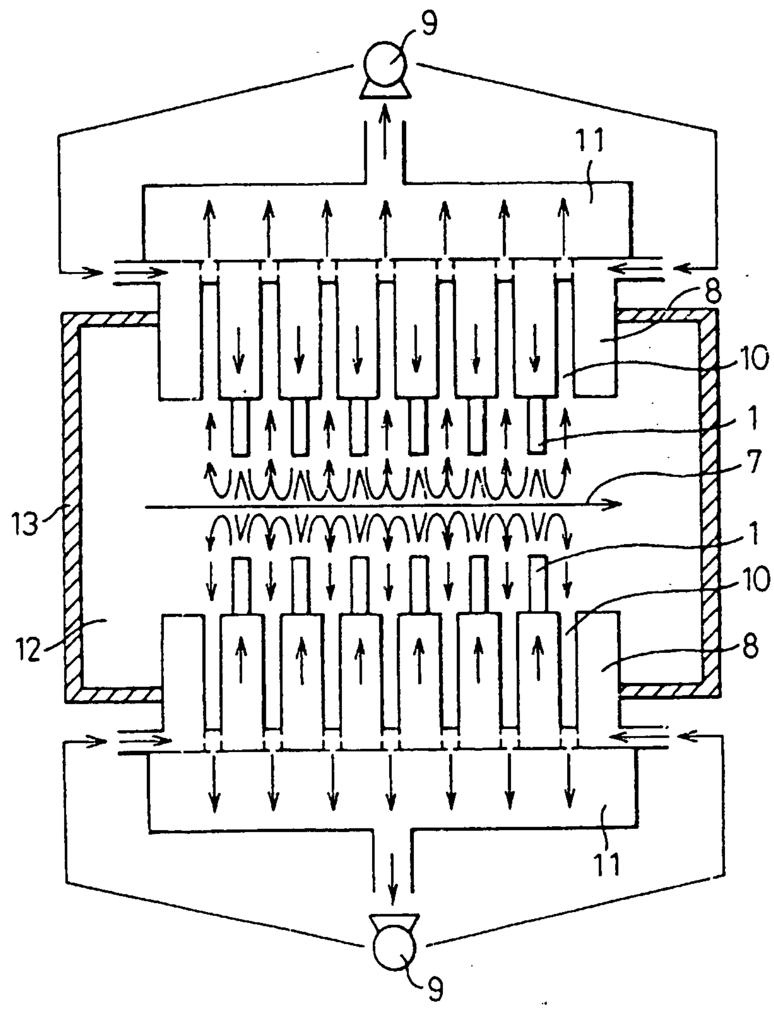


Fig.10(a)

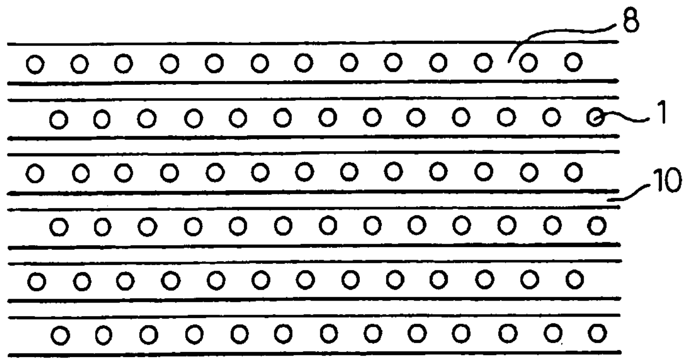


Fig.10(b)

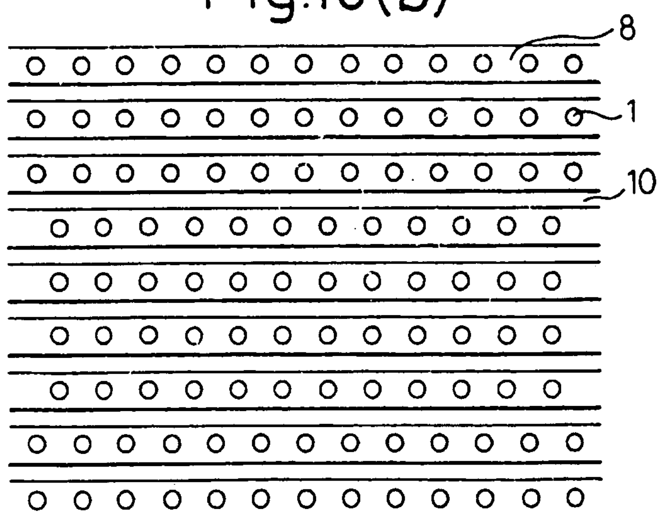


Fig.10(c)

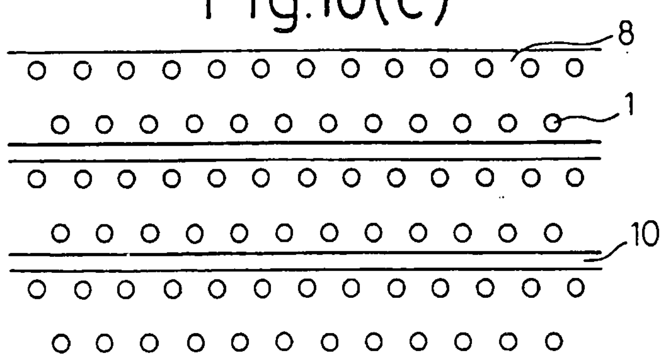


Fig.11

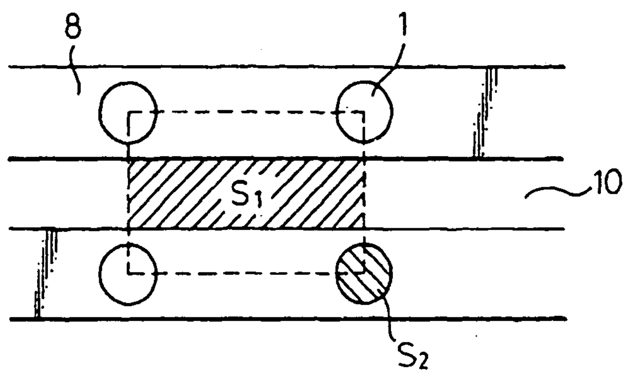

8
1
10
S_1
S_2

Fig.12

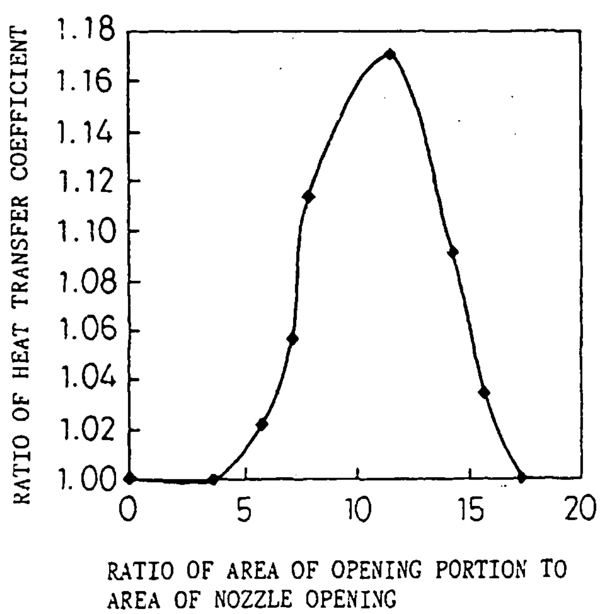

RATIO OF HEAT TRANSFER COEFFICIENT
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0
5
10
15
20
RATIO OF AREA OF OPENING PORTION TO
AREA OF NOZZLE OPENING

Fig.13(a)

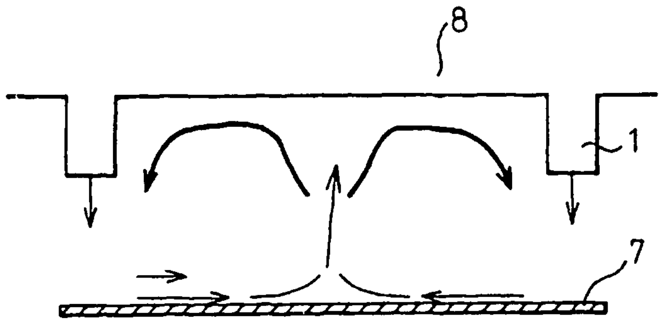


Fig.13(b)

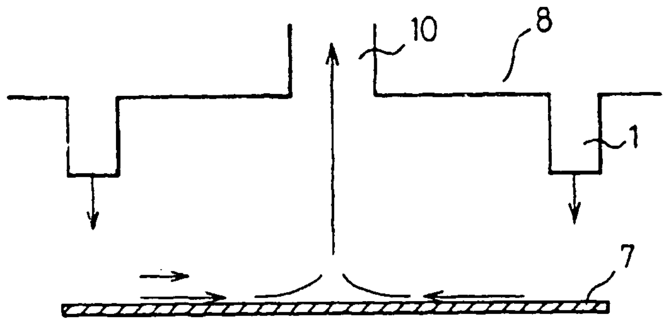


Fig.14

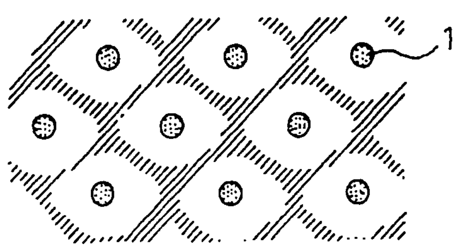


Fig.15(a)

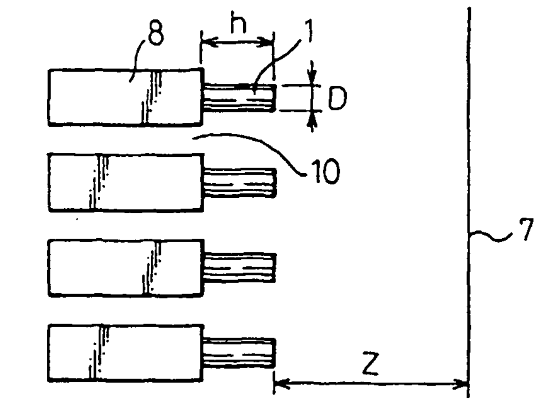


Fig.15(b)

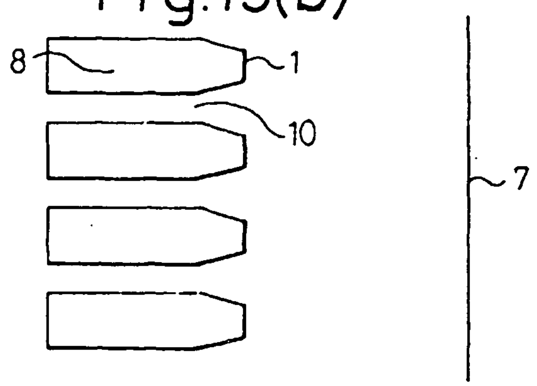


Fig.16

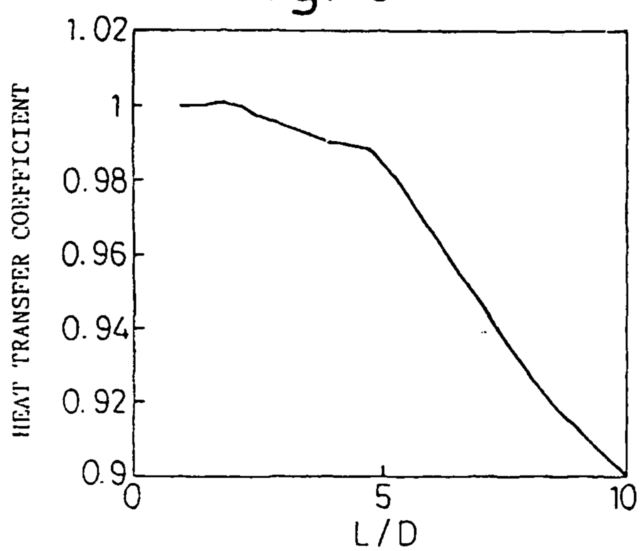


Fig.17

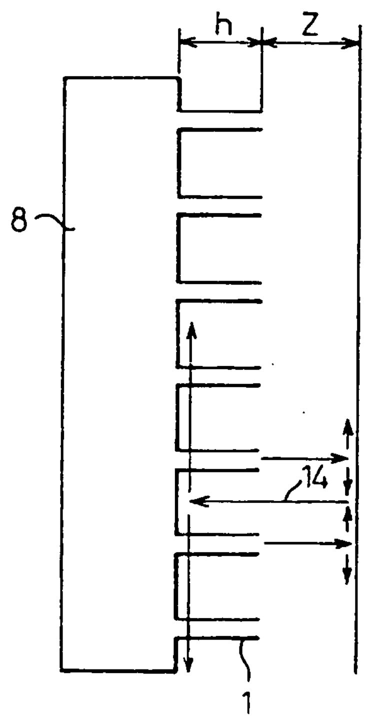


Fig.18

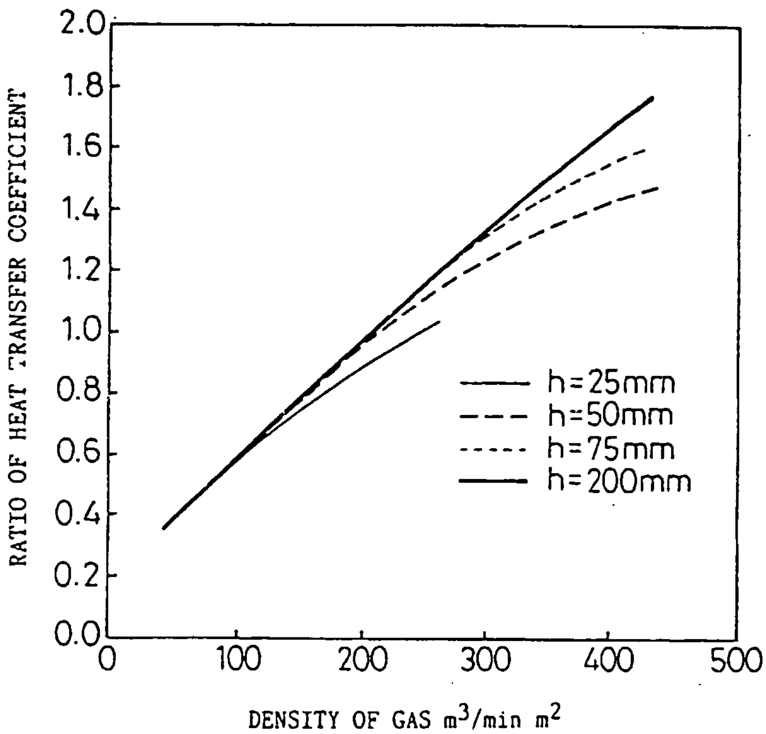

RATIO OF HEAT TRANSFER COEFFICIENT
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
h=25mm
h=50mm
h=75mm
h=200mm
DENSITY OF GAS m3/min m2

Fig.19

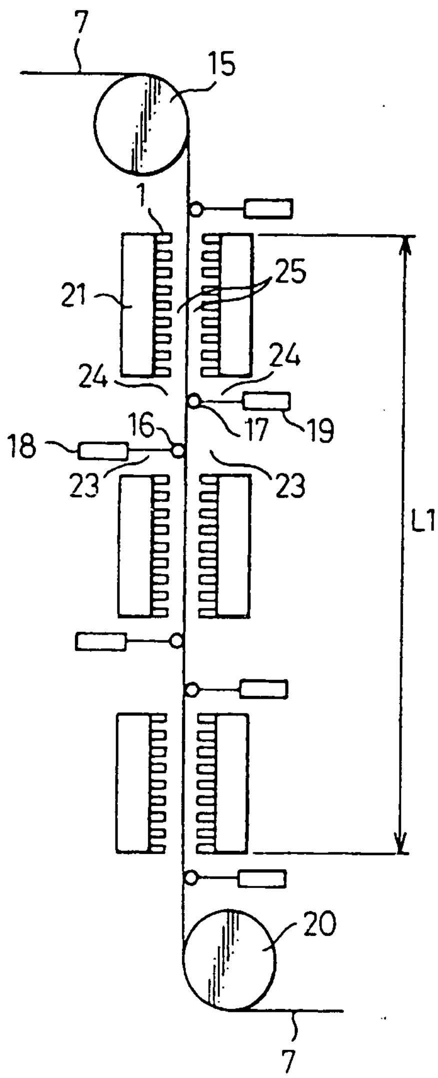


Fig.20

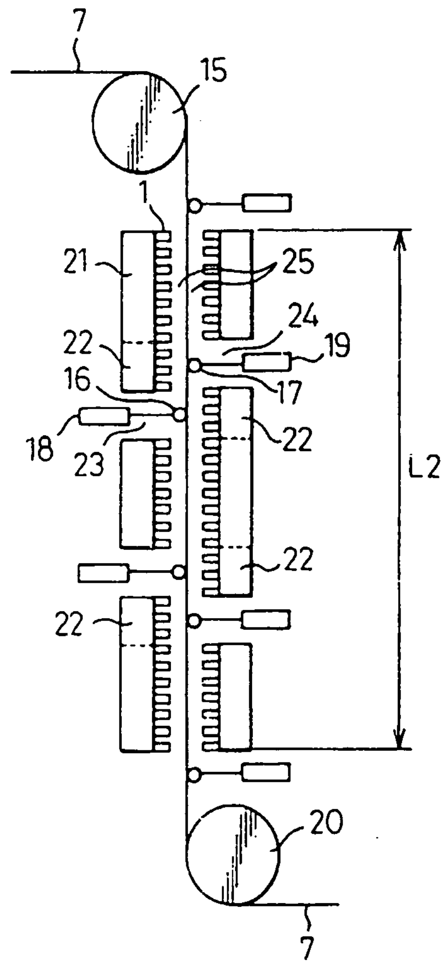


Fig.21

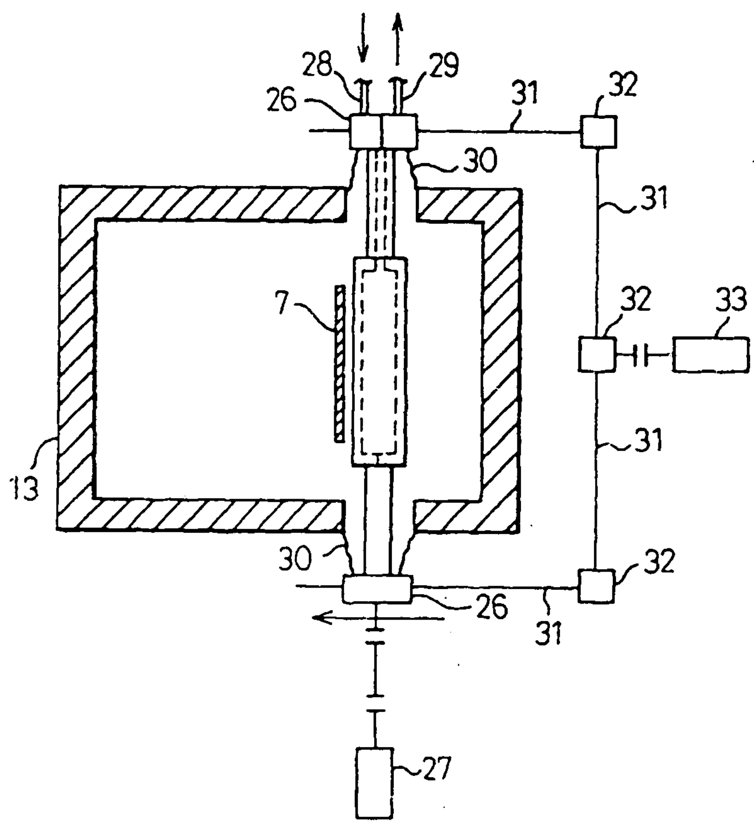


Fig.22(a)

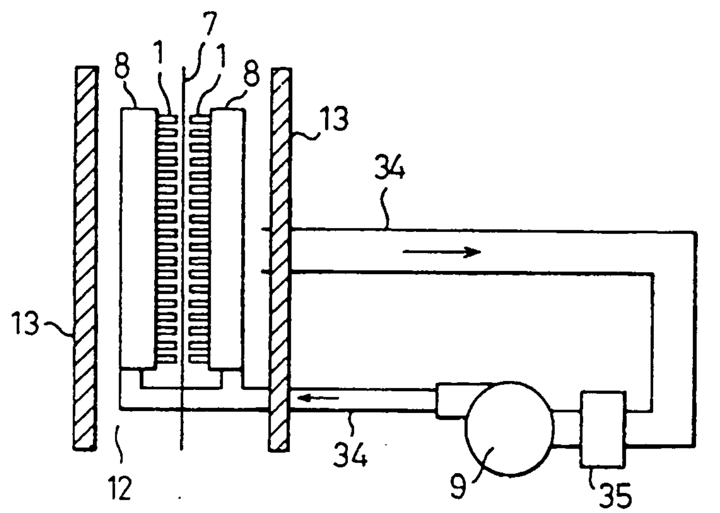


Fig.22(b)

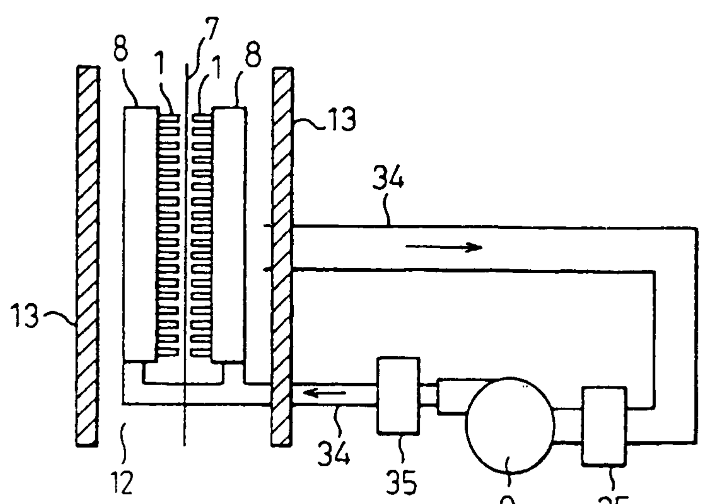
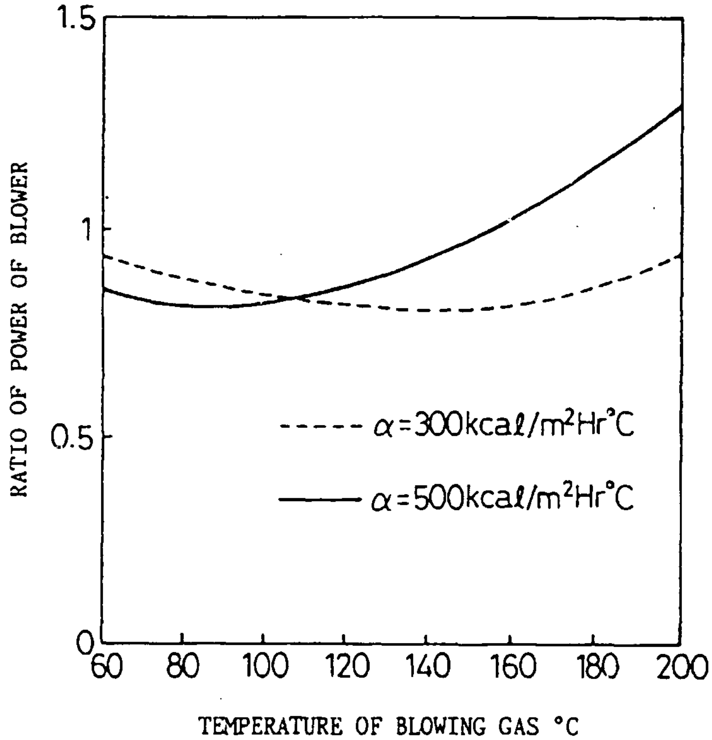


Fig.23



1.5
1
0.5
0
RATIO OF POWER OF BLOWER
60
80
100
120
140
160
180
200
TEMPERATURE OF BLOWING GAS °C
α=300kcal/m²Hr°C
α=500kcal/m²Hr°C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/01072

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] C21D9/56, C21D9/52, C21D9/573

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] C21D9/56, C21D9/52, C21D9/573, B21B45/00, B21B45/02, F26B21/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-1998
Kokai Jitsuyo Shinan Koho	1971-1998	Jitsuyo Shinan Toroku Koho	1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 123744/1984 (Laid-open No. 40155/1986) (Nippon Steel Corp.), March 13, 1986 (13. 03. 86), Claim 1 (Family: none)	1, 2
Y	JP, 4-198424, A (Kawasaki Steel Corp.), July 17, 1992 (17. 07. 92), Claim 1 ; page 2, lower left column, lines 5 to 12 ; Fig. 4 (Family: none)	1, 2, 6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 43332/1990 (Laid-open No. 4052/1992) (Sumitomo Metal Industries, Ltd.), January 14, 1992 (14. 01. 92), Page 9, lines 6 to 20 (Family: none)	1, 2

[x] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search June 5, 1998 (05. 06. 98)	Date of mailing of the international search report June 16, 1998 (16. 06. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/01072

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, Y	JP, 9-194954, A (Nippon Steel Corp.), July 29, 1997 (29. 07. 97), Claim 1 ; column 2, line 38 to column 3, line 8 ; Fig. 1 (Family: none)	3-6
Y	JP, 5-277542, A (NKK Corp.), October 26, 1993 (26. 10. 93), Column 7, lines 18 to 28 ; Fig. 7 (Family: none)	4, 5
A	JP, 2-16375, B2 (Nippon Steel Corp.), April 17, 1990 (17. 04. 90), Claim 1 ; column 7, lines 16 to 22 ; column 10, lines 27 to 32 (Family: none)	7-10
A	JP, 63-241123, A (Sumitomo Metal Industries, Ltd.), October 6, 1988 (06. 10. 88), Claim 1 (Family: none)	7
A	JP, 6-340913, A (NKK Corp.), December 13, 1994 (13. 12. 94), Claim 6 ; column 5, line 46 to column 6, line 16 & EP, 614992, A1	8
A	JP, 4-311535, A (NKK Corp.), November 4, 1992 (04. 11. 92), Column 4, lines 1 to 5 (Family: none)	9
A	JP, 7-26332, A (NKK Corp.), January 27, 1995 (27. 01. 95), Column 11, lines 1 to 5 (Family: none)	10

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